Appendix C
Summary of General Investigation of Tidal Inlets (GITI) Program Reports

C-1. Purpose and Scope

In 1969, the General Investigation of Tidal Inlets (GITI) Program was initiated under the technical surveillance of the U.S. Army Coastal Engineering Research Center (CERC). The GITI Program was established to conduct research into the behavior and characteristics of tidal inlets and to provide quantitative data for use in design of inlets and inlet improvements. Research was conducted by CERC, the U.S. Army Engineer Waterways Experiment Station's Hydraulics Laboratory, other Government agencies, and private organizations. This appendix describes the GITI research program and presents a brief summary of each report published under the program.

C-2. Research Objectives and Design

The GITI Program was divided into three major study areas; inlet classification, inlet hydraulics, and inlet dynamics. A total of 22 reports have been published as part of the GITI series; five related to classification, nine on hydraulic studies, and eight on dynamic studies.

a. Inlet classification. The objective of the inlet classification study was to group inlets according to their geometry, hydraulics, and stability. Early efforts were designed to produce three independent classifications. Plans for future research involved efforts to interrelate the three separate classifications and investigate reasons for correspondence between well-defined classifications. This aspect of the study involved collection of large data sets on the physical characteristics of numerous tidal inlets.

b. Inlet hydraulics. Objectives of the inlet hydraulics study were to define tide-generated flow regime and water level fluctuations in the vicinity of coastal inlets and to develop techniques for predicting these phenomena. The inlet hydraulics study was subdivided into three areas; idealized inlet modeling, evaluation of state-of-the-art physical and numerical models, and prototype inlet hydraulics.

c. Inlet dynamics. Basic objectives of the inlet dynamics study were to investigate the interactions of tidal flow, inlet configuration, and wave action at inlets as a guide to improvement of inlet channels and nearby shore protection works. The study was subdivided into four specific areas; model materials evaluation, movable-bed modeling evaluation, reanalysis of a previous inlet model study, and prototype inlet studies.

C-3. Report Summaries

The following are short summaries of each GITI report in numerical order. Names of authors and date of publication are noted at the end of the summary. Portions of the summaries have been reproduced from abstracts published with the original reports.

GITI Report 1:[1] *Reanalysis of Beach Erosion Board Technical Memorandum No. 94*

In the 1950's, the U.S. Army Beach Erosion Board (BEB)[2] and the U.S. Army Engineer Waterways Experiment Station conducted a series of small-scale model tests to evaluate the impact of an unimproved inlet on adjacent beaches. Test results from six of the eight tests were reported in BEB Technical Memorandum No. 94. A reanalysis of the data, performed under the GITI Program, was originally intended to be the first publication in the GITI series; however, publication was delayed and the report eventually was distributed as a miscellaneous paper by the Hydraulics Laboratory. Reanalysis indicated that the area of the model inlet channel was related to the tidal prism, but the relationship was different from that previously determined by O'Brien for prototype inlets. The reanalysis also showed that the minimum channel area was approximately 80 percent of the average channel area. The Keulegan method was found to be an effective tool for predicting model inlet behavior. TM 94 is included in its entirety as Appendix A for the benefit of those without access to the original report. All data, including those from tests not described in the original report, are also provided in appendices. [E. C. McNair, 1987]

GITI Report 2: Catalog of Tidal Inlet Aerial Photography

This catalog of inlet aerial photography covers inlets on the Pacific, Atlantic, and Gulf coasts and was designed to be an information source for studies of inlet geomorphology and stability. Data from approximately 6,000 inlet overflights dating from 1938 to 1974 (including date,

[1] Published as Miscellaneous Paper HL-87-1.

[2] The Beach Erosion Board is now the Coastal Engineering Research Center (CERC), U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

source agency, project name, exposure numbers, scale, and film type) are presented in tables and indexed according to Corps of Engineer District Office. Exposures for individual date listings are the minimum number necessary to cover the inlet throat and in most cases, are sufficient to identify all associated tidal delta complexes. [J. H. Barwis, 1975]

GITI Report 3: Tidal Prism-Inlet Area Relationships

This report was a secondary result of research conducted as part of the inlet classification study. During an investigation of the variation in the Keulegan repletion coefficient with variations in inlet geomorphology, new tidal prism data were generated. The opportunity was then taken to reexamine relationships originally developed by O'Brien between tidal prism (P) and inlet cross-sectional area (A). A total of 162 data points, representing 108 inlets along the Atlantic, Pacific, and Gulf coasts, were included in the analysis. Data were grouped into three categories according to number of jetties and then further divided based on location (Atlantic, Pacific, or Gulf coast). Regression analysis was performed on each data set to determine best fit relationships. Results yielded equations of the form $A = CP^n$, where C and n are constants. It was determined that unjettied and single-jettied inlets on the three coasts do exhibit different P versus A relationships as a result of the different tidal and wave characteristics of the three coasts. For jettied inlets, it was concluded that no modification of O'Brien's P versus A relationship was warranted by the additional data. [J. T. Jarrett, 1976]

GITI Report 4: Annotated Bibliography on the Geologic, Hydrologic, and Engineering Aspects of Tidal Inlets

This report contains citations for approximately 1,000 published and unpublished documents on geologic and engineering aspects of tidal inlets. References were collected during a literature survey made as background for the inlet classification aspect of the investigation and include reports on tidal hydraulics, inlet structures, littoral processes, inlet stratigraphy and geologic history, coastal aerial photography, and inlet case studies. References are listed alphabetically by last name of the senior author and a cross-referenced subject index is provided. [J. H. Barwis, 1976]

GITI Report 5: Notes on Tidal Inlets on Sandy Shores

This report presents an edited collection of observations and theories on several aspects of tidal inlets prepared by M. P. O'Brien during 40 years of inlet-related work. These notes were originally intended only to help a graduate student formulate a research project; however, it was believed that they could serve as a valuable addition to the GITI publication series and would stimulate further inlet research. [M. P. O'Brien, 1976]

GITI Report 6: Comparison of Numerical and Physical Models, Masonboro Inlet, North Carolina

GITI Report 6 presents an evaluation of existing inlet modeling techniques performed by calibrating a physical model and three numerical models with prototype data from Masonboro Inlet. Model verification was not conducted since no additional prototype data were available. A distorted scale fixed-bed physical model, a lumped parameter numerical model, and two two-dimensional numerical models were included in the study. To extend the model comparison, the two-dimensional, shallow-water hydrodynamic equations were derived from the Navier-Stokes equations and the physical interpretation and significance of each term were discussed. Study results indicated that the four models more accurately simulated tidal height than tidal current. It was concluded that physical models provide more reliable predictions than numerical models of the effect of small-scale phenomena. On the other hand, numerical models can provide better predictions of the effects of the earth's rotation, wind stress, and pressure gradients. Reports on each of the four models investigated were published as separate appendixes to the main report. [D. L. Harris and B. R. Bodine, 1977, Main text and Appendices 1-4]

GITI Report 7: Model Materials Evaluation; Sand Tests; Hydraulic Laboratory Investigation

A recognized need in making movable-bed inlet modeling a precise science was a better understanding of the model relationships between the fluid motions, sediment, and resulting inlet characteristics. This report summarizes a series of 21 laboratory tests conducted in a partitioned flume with a 40-ft-long test section of beach including an inlet. Since stable and definable flow conditions were considered essential for the tests, a series of steady unidirectional flows was substituted for cyclic tidally induced flows. Tests consisted of various steady discharges through the inlet with and without waves acting on the seaward end of the channel. Surveys of the inlet were taken periodically to evaluate changes in channel geometry. Tests indicated that minimum channel area, channel width, and the hydraulic radius were strongly related to rate of flow through the channel. The ability to scale channel geometry was demonstrated; however, it was determined that scaling relations for material transport required further investigation. The report also presents specific recommendations for improved test procedures for future model material studies. [E. C. McNair, 1976]

GITI Report 8: Hydraulics and Dynamics of New Corpus Christi Pass, Texas: A Case History, 1972 - 1973

Corpus Christi Water Exchange Pass extends from Corpus Christi Bay to the Gulf of Mexico through Mustang Island, Texas. Studies of sedimentation and hydraulics of the pass began with its opening in 1972 and continued through 1975. This report presents data on the initial adjustment (1 year) of the pass to tides, waves, and other forces. It was estimated that approximately 1 million yd^3 of sand accumulated at the pass during construction of the two jetties. Downdrift beaches exhibited considerable sand loss and extensive shoal deposits formed near the bay end of the pass. Average discharge through the pass was only about 3 percent of the total tidal prism, indicating that Aransas Pass to the north was the primary bay-gulf connection and that the creation of Corpus Christi Pass had no significant effect on flushing of the bay. Work on this research was conducted by the University of Texas Marine Science Institute. [E. W. Behrens, R. L. Watson, and C. Mason, 1977]

GITI Report 9: Hydraulics and Dynamics of New Corpus Christi Pass, Texas: A Case History, 1973 - 1975

Data obtained during the second phase (1973-1975) of a field study of Corpus Christi Water Exchange Pass are presented in this report. Qualitative and quantitative data on longshore sediment transport, tidal differentials, flood and ebb tidal discharge, wind waves, and local winds provided information on both the long- and short-term stability of the pass and on the processes affecting the dynamics of the pass and adjacent beaches. It was determined that the flood dominant nature of the system, together with a long channel, required that most sediment entering the channel be carried through its entire length to be deposited on the flood-tidal delta if the pass was to remain open. Results of stability analyses suggested that the pass was of marginal stability with a tendency toward closure. [R. L. Watson and E. W. Behrens, 1976]

GITI Report 10: Hydraulics and Dynamics of North Inlet, South Carolina, 1974 - 1975

This report presents results of the first phase of a field study to define the hydraulics and dynamics of North Inlet, South Carolina. Field work was conducted quarterly to characterize seasonal variations and included a general reconnaissance of the inlet area, beach profile surveys, bathymetric mapping, tidal elevation and current velocity measurements, and aerial photography. The importance of seasonal variation in processes was emphasized by significant differences in wave parameters, short-term morphologic response, and tidal parameters. [R. J. Finley, 1977]

GITI Report 11: Laboratory Investigation of Tidal Inlets on Sandy Coasts

This report is based on a series of 36 experiments conducted at the Hydraulic Engineering Laboratory at the University of California, Berkeley. Experiments were performed in an idealized movable-bed tidal inlet model for a variety of geometric characteristics. Sinusoidal tides and model waves were run until a periodic tide was established in the bay. Measured parameters included cross-sectional area; water surface elevations of the ocean, bay, and inlet; and inlet velocities. Results indicated that two techniques accurately predicted idealized inlet hydraulics; Keulegan's repletion coefficient technique, and the lumped parameter method which extends the Keulegan method by considering inertia and variable inlet geometry. Experimental data are presented in tables, photographs, and plots. Comparisons of tidal prisms and minimum flow areas between laboratory results and field data are also presented. [R. E. Mayor-Mora, 1977]

GITI Report 12: A Case History of Port Mansfield Channel, Texas

This report documents the hydraulic and sedimentary characteristics of Port Mansfield Channel and presents an evaluation of its behavior from construction in 1962 to 1975. The channel is an artificial, jettied inlet on the Texas coast connecting the Gulf of Mexico with Laguna Madre. Seaward migration of the updrift shoreline and shoaling in the entrance channel suggested that material was bypassing the jetty. Significant annual dredging was necessary to maintain design channel dimensions. Predictions of stability using relationships developed by Escoffier, O'Brien, and Bruun and Gerritsen were found to predict the unstable nature of the inlet. Keulegan's repletion coefficient was calculated to investigate the hydraulic capacity of the channel; a value of 0.57 indicated that infilling of the bay would be incomplete. It was also determined that channel velocities were not sufficient to cause natural scour and maintain the design cross-sectional area. The instability of the inlet was attributed to the large head loss due to friction in the extremely long channel. [J. M. Kieslich, 1977]

GITI Report 13: Hydraulics and Stability of Tidal Inlets

Classic inlet hydraulic and stability work by Brown, O'Brien, Escoffier, Bruun, Keulegan, O'Brien and Dean, Johnson, and Jarrett is summarized in this report. The original stability concept is extended and functional design requirements are discussed. In addition, case studies of Masonboro Inlet, North Carolina, Rollover Fish Pass, Texas, and Mission Bay Inlet, California, are presented. [F. F. Escoffier, 1977]

GITI Report 14: A Spatially Integrated Numerical Model of Inlet Hydraulics

This report discusses development of a simple numerical model for the prediction of inlet channel velocities and discharge as well as resulting bay surface level fluctuations for inlets responding to the tide and other long wave oscillations. The model simultaneously solves the area-averaged momentum equation for the inlet and the continuity equation for the bay. The bay surface elevation is assumed to remain horizontal during rise and fall. At each time-step, the geometric and hydraulic factors describing the inlet-bay system are calculated by evaluating flow conditions throughout the inlet and by spatially integrating this information to determine coefficients of the first-order differential equations. The model was determined to be flexible and to give realistic estimates of inlet-bay hydraulics. [W. N. Seelig, D. L. Harris, and B. E. Herchenroder, 1977]

GITI Report 15: Physical Model Simulation of the Hydraulics of Masonboro Inlet, North Carolina

This report is the first of two publications presenting detailed results of the Masonboro Inlet fixed-bed model study. The model study was conducted to determine the ability of existing physical modeling techniques to simulate hydraulic characteristics of an inlet-bay system and to determine whether simple tests could be useful in predicting the effects of proposed inlet improvements. This report presents model verification and prediction data as well as analyses concerning the effects of waves on model hydraulics. Five velocity ranges with three stations at each range were verified in the model; seven tidal elevation gauges in the ocean and bay were also verified. Model predictions of filling of the dredged navigation channel and deposition basin, and a tendency for the channel to shift toward the north jetty were substantiated by comparison with prototype data. [R. A. Sager and W. C. Seabergh, 1977]

GITI Report 16: Hydraulics and Dynamics of North Inlet, South Carolina

This report presents results of the second phase of a field study to define the hydraulics and dynamics of North Inlet, South Carolina. Detailed bathymetric profiling of the inlet throat and channels and topographic mapping of subaerial, intertidal, and shallow subtidal zones were used to define the seasonal morphologic variability of the inlet and adjacent beaches. Wave and tidal data provided basic information on wave conditions and inlet hydraulic characteristics and were correlated with observed bathymetric changes. Results presented in this report suggested that North Inlet was hydraulically ebb dominated; peak ebb velocity exceeded peak flood by a factor of 1.22. In a multiple stepwise regression analysis, the longshore component of wind velocity was found to explain more of the variance in the observed longshore current velocity than any other measured parameter. [D. Nummedal and S. M. Humphries, 1978]

GITI Report 17: An Evaluation of Movable-Bed Tidal Inlet Models

The objectives of this study were to evaluate the effectiveness of movable-bed tidal inlet hydraulic models in predicting prototype behavior and to examine the scaling requirements for such models. Seven model studies, conducted at WES between 1939 and 1969, were evaluated. Calibrations of five of the models, as measured by bed topography changes, were evaluated using correlation coefficients and root-mean-square (rms) error. Due in part to inadequate prototype data, acceptable model performance was not always achieved; values of correlation coefficients were typically low and those of rms error high. A literature review was also performed to determine the present understanding of and practice concerning similitude requirements for movable-bed coastal models. Major capabilities and limitations of movable-bed inlet models are discussed and an assessment of the general conditions and similitude requirements under which inlet models may be expected to yield reliable results are outlined. The study was conducted at the Iowa Institute of Hydraulic Research, The University of Iowa. [S. J. Jain and J. F. Kennedy, 1979]

GITI Report 18: Supplementary Tests of Masonboro Inlet Fixed-Bed Model

This report is the second concerned with testing in the Masonboro Inlet fixed-bed physical model and describes three separate supplemental test series. The first study examined the effects of closing various bay channels on inlet hydraulics. The second investigated the effects of adding a south jetty to the existing project, which had a single north jetty, and included an evaluation of the resulting hydraulics for various weir configurations on both jetties. The third study involved sediment tracer testing under the action of tides and wind waves and was designed to evaluate the effectiveness of using tracer materials in inlet model studies. Results indicated that the closure of any of the three interior channels in Masonboro Inlet produced a significant change in inlet hydraulics and morphology. Weir jetty testing indicated the effect of a south jetty was to centralize flood flow through the inlet gorge, and the presence of a weir on the south jetty did not alter the basic flow pattern. Tracer experiments showed that short-term fill and scour trends could be predicted qualitatively; however, major changes in bathymetry preclude quantitative long-range predictions. [W. C. Seabergh and R. A. Sager, 1980]

GITI Report 19: Tidal Inlet Response to Jetty Construction

During an evaluation of inlet models, a similarity in channel and beach response to jetty construction at Tillamook Bay, Oregon, and Masonboro Inlet, North Carolina, was noted. An effort was then undertaken to determine if the response pattern exhibited by these two inlets was typical of other inlets on U.S. coasts. This report presents results of that investigation. Thirteen tidal inlets located on the Atlantic, Gulf, and Pacific coasts of the continental United States were selected for study. Inlet entrance behavior following jetty construction was evaluated, and guidelines for the functional design of inlet entrance improvements are suggested. Inlets considered in the study were those where a single updrift or downdrift jetty was built first. The construction of single jetties resulted in migration of the channel thalweg toward the jetty regardless of the inlet-bay orientation, angle of the jetty to the shoreline, position of the jetty relative to the direction of net longshore transport, the ratio of net-to-gross transport, or the gross transport. Accretion of the updrift shoreline, erosion of the downdrift shoreline, and a decrease in channel cross-sectional area typically followed construction of an updrift jetty. Sufficient data were not available to generalize response following construction of a downdrift jetty. [J. M. Kieslich, 1981]

GITI Report 20: Geometry of Selected U.S. Tidal Inlets

This report presents a classification of inlets based on objective analysis of similarities between inlet geometric (morphologic) characteristics. Characteristics of the inlet throat and ebb delta of 67 U.S. tidal inlets were investigated. Thirteen parameters indicative of tidal geometry were defined and measured with correlations developed. The parameters are shown to vary in a consistent fashion that appears to be scaled according to the relative magnitude of tidal processes. Results of both cluster analysis and discriminate analysis indicate the presence of at least six well-defined clusters or types of inlets based on geometry. The classification provides a systematic organization of inlet morphology that is related to deviations from the basic scaling relationship probably due to the influence of wave action. The report contains substantial amounts of inlet morphologic data obtained from aerial photographs and boat sheets that may be applicable to site-specific studies. [C. L. Vincent and W. D. Corson, 1980]

GITI Report 21: Stability of Selected U.S. Tidal Inlets

This report presents a study of tidal inlet stability based on changes in geomorphic parameters measured from aerial photographs. A total of 51 inlets were selected for study, representing the range of inlets along U.S. coasts. Years of photographic coverage include 1938 through 1976. Hydraulic and geographic (positional) stability parameters were defined, measured, and used to create four stability indices describing the relative variation of principal aspects in which inlets can be expected to change in time. A single parameter was devised to indicate hydraulic stability and another for positional stability. Arbitrary stability limits were then selected and all inlets classified as stable or unstable. Regional patterns of inlet stability were also investigated; however, no strong correlation was found. Data presented in this report will be valuable in future studies of relationships between inlet geomorphic changes and appropriate hydraulic parameters. [C. L. Vincent, W. D. Corson, and K. J. Gingerich, 1991]

GITI Report 22: Evaluation of Physical and Numerical Hydraulic Models, Masonboro Inlet, North Carolina

GITI Report 22 is the last in a series of documents describing the calibration and verification of the physical model and several numerical models of Masonboro Inlet. This report presents a comparison of the predictions of a fixed-bed, distorted-scale physical model, a two-dimensional, vertically integrated numerical model, and a spatially integrated numerical model with a set of July 1974 prototype data. Both the physical model and the two-dimensional model reproduced measured tidal records and vertically averaged velocities equally well.

Predictions from the two models and the prototype data were averaged for comparison with the spatially integrated model. The spatially integrated model predicted mean inlet velocities significantly better than the other two models; however, it did not predict the average bay levels as well. In addition, the author presents possible ways to improve results of each of the three models. [J. E. McTamany, 1982]